CHAPTER 15

PRACTICE EXERCISES

SECTION I MULTIPLE CHOICE

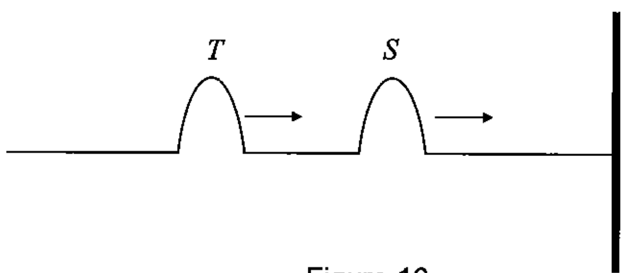


Figure 16

1. Two pulses on a string move to the right as shown in the figure. When pulse S reflects from the fixed end of the string and interferes with T, the shape of the resulting pulse is best described by

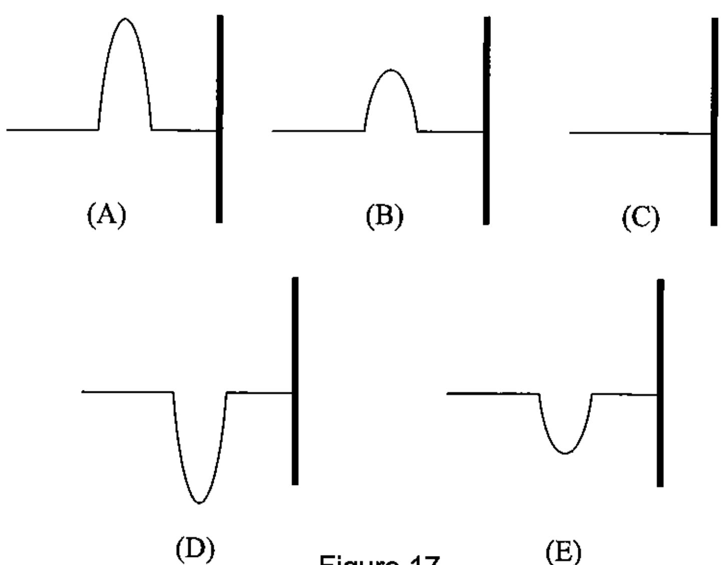


Figure 17

2. A sound source produces waves of frequency f on a day when the speed of sound is v_s. The sound experienced by a stationary observer as this source moves away from the observer will have frequency and wave speed f', v_s'. Which of the following is true?

(A) $f' > f$, $v_s' = v_s$ (B) $f' < f$, $v_s' = v_s$ (C) $f' < f$, $v_s' < v_s$
(D) $f' > f$, $v_s' > v_s$ (E) $f' > f$, $v_s' < v_s$

Questions 3 and 4

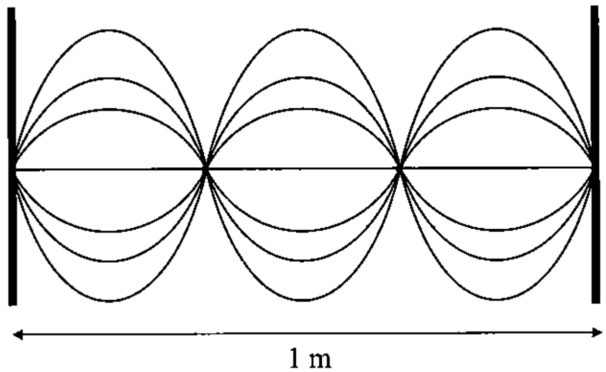


Figure 18

3. The standing wave shown in the figure has a frequency of 6 Hz. The wave speed on the string is most nearly

(A) 2 m/s (B) 4 m/s (C) 6 m/s (D) 8 m/s (E) 10 m/s

4. The fundamental frequency of the string is

(A) 3 Hz (B) 1 Hz (C) 6 Hz (D) 12 Hz (E) 2 Hz

5. A hollow tube of length 3 m is open at both ends. A sound source emitting waves of which wavelength will not produce a standing wave in the tube?

(A) 1 m (B) 2 m (C) 3 m (D) 4 m (E) 6 m

6. A sound source emitting waves of frequency 250 Hz is placed near a guitar that has 6 strings of length 0.9 m. When the source is turned off, you notice that one of the strings continues to vibrate with one antinode present. The wave speed on this string is most nearly

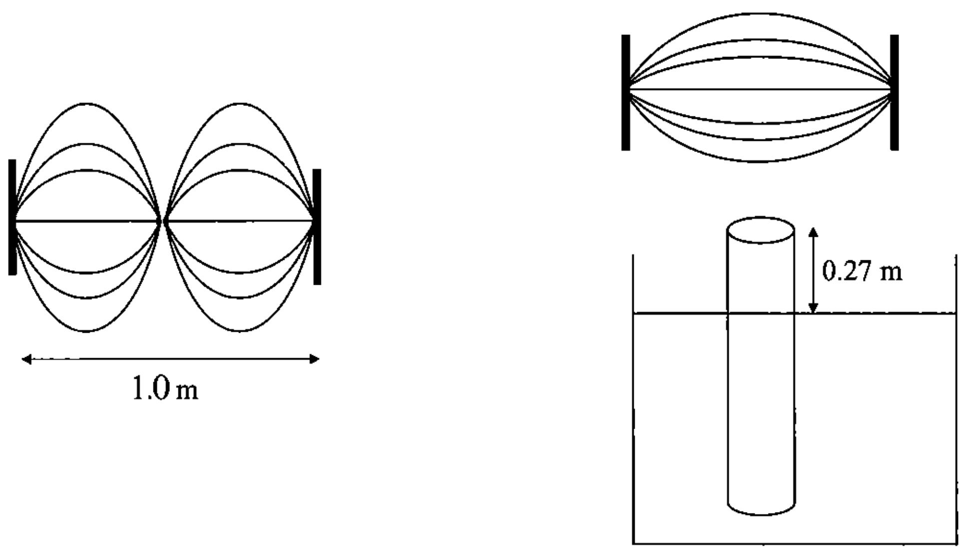
(A) 340 m/s (B) 110 m/s (C) 220 m/s (D) 440 m/s (E) 170 m/s

7. A piano tuner has a set of precision tuning forks. A colleague gives him a tuning fork with no frequency markings on it. When he sounds the unknown with a 496 Hz tuning fork, he hears a beat frequency of 3 Hz. When he sounds it with a 484 Hz tuning fork, he hears a beat frequency of 9 Hz. The frequency of the unknown tuning fork is

(A) 499 Hz (B) 490 Hz (C) 475 Hz (D) 493 Hz (E) 487 Hz

CHAPTER 15 PRACTICE EXERCISES

SECTION II FREE RESPONSE



(a) Figure 19 (b)

1. A sound source producing waves of frequency 600 Hz causes a 1.0 m string with fixed ends to vibrate in a standing wave pattern, shown in the figure on the left. When the same string is simply plucked so that it vibrates in its fundamental mode, it will first resonate with a long, hollow tube immersed in water when the tube is withdrawn 0.27 m from the water.

   (a) Determine the wave speed on the string.
   (b) Determine the speed of sound from the data given.
   (c) If the string continues to vibrate in its fundamental mode, how far must the tube be raised out of the water to reach another resonance?

Answers and Explanations

MULTIPLE CHOICE

1. The answer is C. The reflected pulse S will invert upon reflection. As it passes through the pulse T, their opposite orientation will lead to destructive interference.

2. The answer is B. This is the moving source Doppler effect. As the source moves away from the observer, the wavelength gets longer, but the wave speed stays the same since the wave speed depends on only the medium properties. Since $v_s = \lambda' f'$, a larger wavelength means a lower frequency.

3. The answer is B. From the figure, you can see that the wavelength of the standing wave is $\frac{2}{3}$ m . Then, $v_{st} = \lambda f \Rightarrow v_{st} = \frac{2}{3}(6) = 4\frac{\text{m}}{\text{s}}$.

4. The answer is E. The fundamental mode will have one antinode between the two nodes at the ends. The full length of the string will support $\frac{1}{2}$ wavelength, so $\lambda = 2$ m. The wavespeed will still be 4 m/s, so you have $f = \frac{v_{st}}{\lambda} = \frac{4}{2} = 2\text{Hz}$.

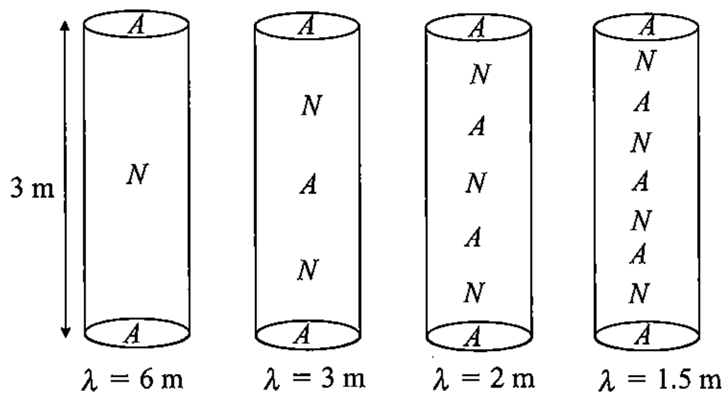


Figure 20

5. The answer is D. Since there must be an antinode at each end, the sequence of possible standing waves is shown in the figure. Because each N-A interval is $\frac{1}{4}\lambda$, simple counting leads to the wavelengths shown in the figure. 4 m isn't possible.

6. The answer is D. This is a resonance, so the frequency of the string wave will be 250 Hz. The string is vibrating in its fundamental mode, so the wavelength will be 1.8 m. Then, $v = \lambda f = (1.8)(250) = 450$ Hz.

7. The answer is D. Since $f_{\text{beat}} = |f_1 - f_2|$, a beat frequency of 3 Hz with a 496 Hz fork means the unknown fork has a frequency of either 493 Hz or 499 Hz. A beat frequency of 9 Hz with a 484 Hz fork means the unknown fork is either 493 Hz or 475 Hz. Together, only 493 Hz is possible.

FREE RESPONSE

1. (a) From the figure, you can see that the wavelength of the standing wave is the same as the string length, 1.0 m. Since this is a resonance, the frequency of the string wave is the same as the sound source, so

$$v_{st} = \lambda f = (1.0)(600) = 600 \text{ m/s}$$

(b) The frequency of the string in the fundamental mode will be 300 Hz because the wavelength is now twice as long. This will also be the frequency of the standing sound wave set up in the tube. Since this tube has one end closed and one end open, the fundamental frequency is $f_1 = \frac{v_s}{4L}$. Then you have

$$300 = \frac{v_s}{4(0.27)} \Rightarrow v_s = 324 \text{ m/s}$$

(c) To excite another standing wave in the tube with the same frequency, you can draw it out of the water until the third harmonic of the new length matches the 300 Hz driving frequency. For a tube with one end closed, the third harmonic has a frequency of

$$f_2 = 3\frac{v_s}{4L}$$

Then you have

$$300 = 3\frac{v_s}{4L} = 3\frac{324}{4L} \Rightarrow L = 0.81 \text{ m}$$